



Karlsruhe Chart of the Nuclides Nuclear Data

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**Institute for Transuranium Elements - Karlsruhe
Joint Research Centre**



Overview

Nuclide Charts

Karlsruhe Chart of Nuclides

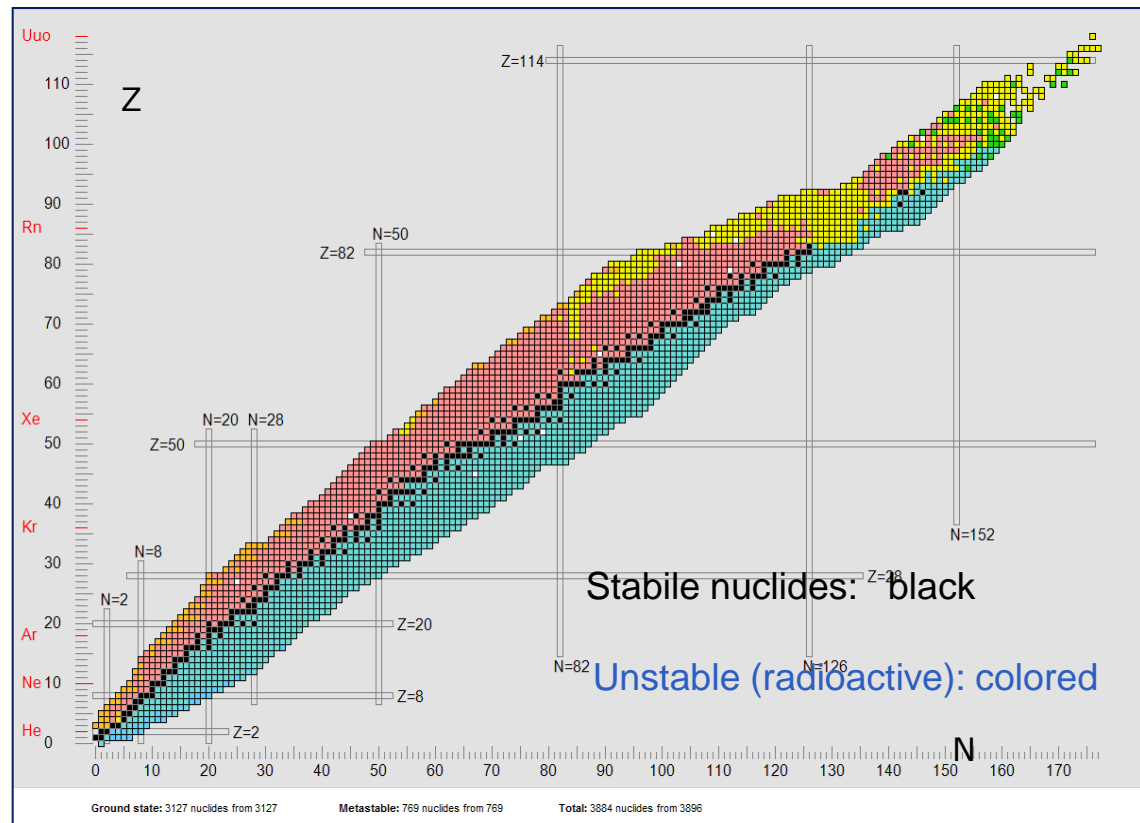
Electronic Nuclide Charts in Nucleonica

Nuclear Data Search in Nucleonica

What is a Nuclide Chart?

Nuclide charts are essentially a plot of the number of protons versus the number of neutrons in atomic nucleus.

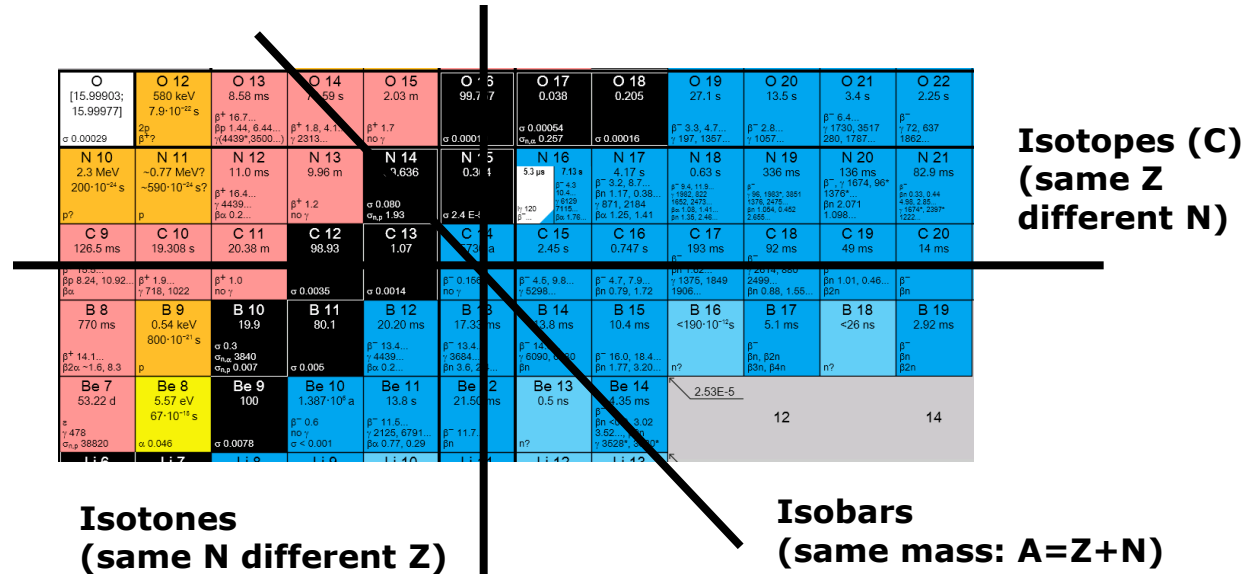
Stable nuclides fall in a narrow range of neutron to proton ratio. The stability of nuclei is extremely significant for special (magic) number of protons and neutrons.



Nuclide boxes

The charts contain information on the basic properties of known nuclides.

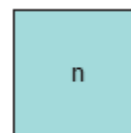
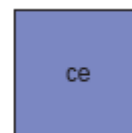
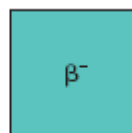
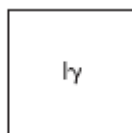
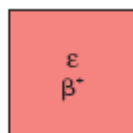
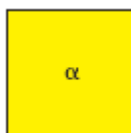
Each nuclide is represented by a box containing basic nuclear data



This data consists of the half-life, neutron cross sections, main gamma lines, etc... An important characteristic of the chart is the use of colours to denote the mode of decay, half-life, or cross-sections. If the nuclide has one or more metastable states, the box is subdivided into smaller boxes for each state.

KNC – Colours of decay modes

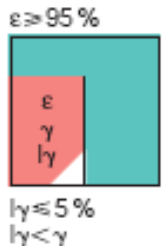
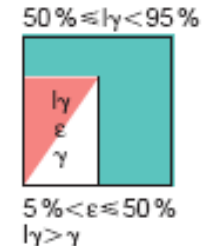
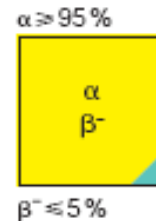
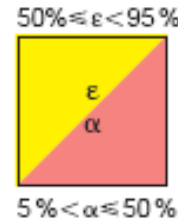
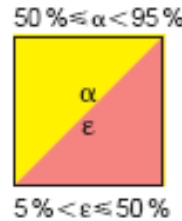
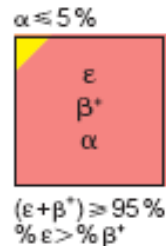
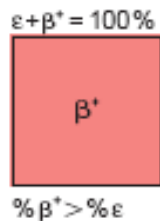
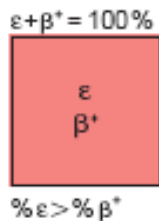
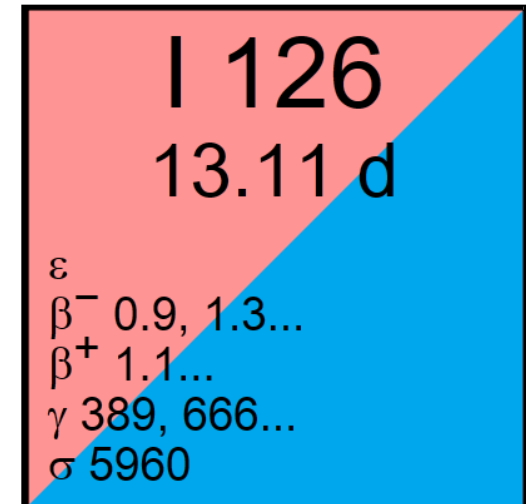
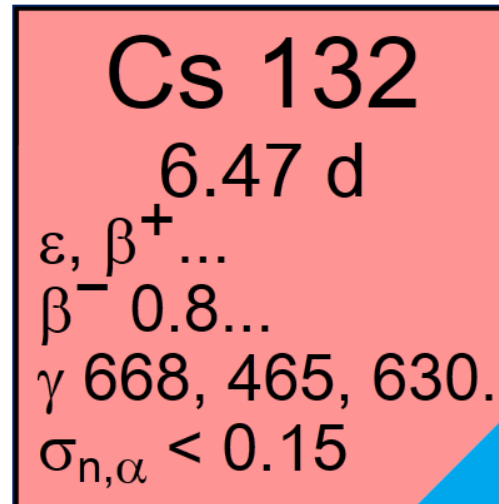
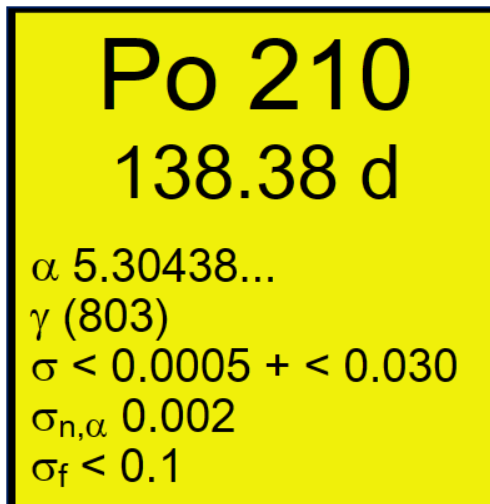
O [15.99903; 15.99977] σ 0.00029	O 12 580 keV $7.9 \cdot 10^{-22}$ s 2p β^+ ?	O 13 8.58 ms β^+ 16.7... βp 1.44, 6.44... γ (4439*,3500...)	O 14 70.59 s β^+ 1.8, 4.1... γ 2313...	O 15 2.03 m β^+ 1.7 no γ	O 16 99.757 σ 0.00019	O 17 0.038 σ 0.00054 $\sigma_{n,\alpha}$ 0.257	O 18 0.205 σ 0.00016	O 19 27.1 s β^- 3.3, 4.7... γ 197, 1357...	O 20 13.5 s β^- 2.8... γ 1057...	O 21 3.4 s β^- 6.4... γ 1730, 3517 280, 1787...	O 22 2.25 s β^- γ 72, 637 1862...
N 10 2.3 MeV $200 \cdot 10^{-24}$ s p?	N 11 ~0.77 MeV? ~ $590 \cdot 10^{-24}$ s? p	N 12 11.0 ms β^+ 16.4... γ 4439... $\beta\alpha$ 0.2...	N 13 9.96 m β^+ 1.2 no γ	N 14 99.636 σ 0.080 $\sigma_{n,p}$ 1.93	N 15 0.364 σ 2.4 E-5	N 16 5.3 μ s 7.13 s β^- 4.3 10.4... γ 6129 7115... $\beta\alpha$ 1.76...	N 17 4.17 s β^- 3.2, 8.7... βn 1.17, 0.38... γ 871, 2184 $\beta\alpha$ 1.25, 1.41	N 18 0.63 s β^- 9.4, 11.9... γ 1982, 822 1652, 2473... $\beta\alpha$ 1.08, 1.41... βn 1.35, 2.46...	N 19 336 ms β^- γ 96, 1983*, 3851 1376, 2475... βn 1.054, 0.462 2.655...	N 20 136 ms β^- , γ 1674, 96* 1376*... βn 2.071 1.098...	N 21 82.9 ms β^- βn 0.33, 0.44 4.98, 2.85... γ 1674*, 2397* 1222...
C 9 126.5 ms β^+ 15.5... βp 8.24, 10.92... $\beta\alpha$	C 10 19.308 s β^+ 1.9... γ 718, 1022	C 11 20.38 m β^+ 1.0 no γ	C 12 98.93 σ 0.0035	C 13 1.07 σ 0.0014	C 14 5730 a β^- 0.156 no γ	C 15 2.45 s β^- 4.5, 9.8... γ 5298...	C 16 0.747 s β^- 4.7, 7.9... βn 0.79, 1.72	C 17 193 ms β^- βn 1.62... γ 1375, 1849 1906...	C 18 92 ms β^- γ 2614, 880 2499... βn 0.88, 1.55...	C 19 49 ms β^- βn 1.01, 0.46... $\beta 2n$	C 20 14 ms β^- βn
B 8 770 ms β^+ 14.1... $\beta 2\alpha$ ~1.6, 8.3	B 9 0.54 keV $800 \cdot 10^{-21}$ s p	B 10 19.9 σ 0.3 $\sigma_{n,\alpha}$ 3840 $\sigma_{n,p}$ 0.007	B 11 80.1 σ 0.005	B 12 20.20 ms β^- 13.4... γ 4439... $\beta\alpha$ 0.2...	B 13 17.33 ms β^- 13.4... γ 3684... βn 3.6, 2.4...	B 14 13.8 ms β^- 14.0... γ 6090, 6730 βn	B 15 10.4 ms β^- 16.0, 18.4... βn 1.77, 3.20...	B 16 < $190 \cdot 10^{-12}$ s n?	B 17 5.1 ms β^- βn , $\beta 2n$ $\beta 3n$, $\beta 4n$	B 18 <26 ns n?	B 19 2.92 ms β^- βn $\beta 2n$
Be 7 53.22 d ϵ γ 478 $\sigma_{n,p}$ 38820	Be 8 5.57 eV $67 \cdot 10^{-18}$ s α 0.046	Be 9 100 σ 0.0078	Be 10 $1.387 \cdot 10^6$ a β^- 0.6 no γ σ < 0.001	Be 11 13.8 s β^- 11.5... γ 2125, 6791... $\beta\alpha$ 0.77, 0.29	Be 12 21.50 ms β^- 11.7... βn	Be 13 0.5 ns n?	Be 14 4.35 ms β^- βn <0.8, 3.02 3.52..., $\beta 2n$ γ 3528*, 3680*	2.53E-5 12 14			



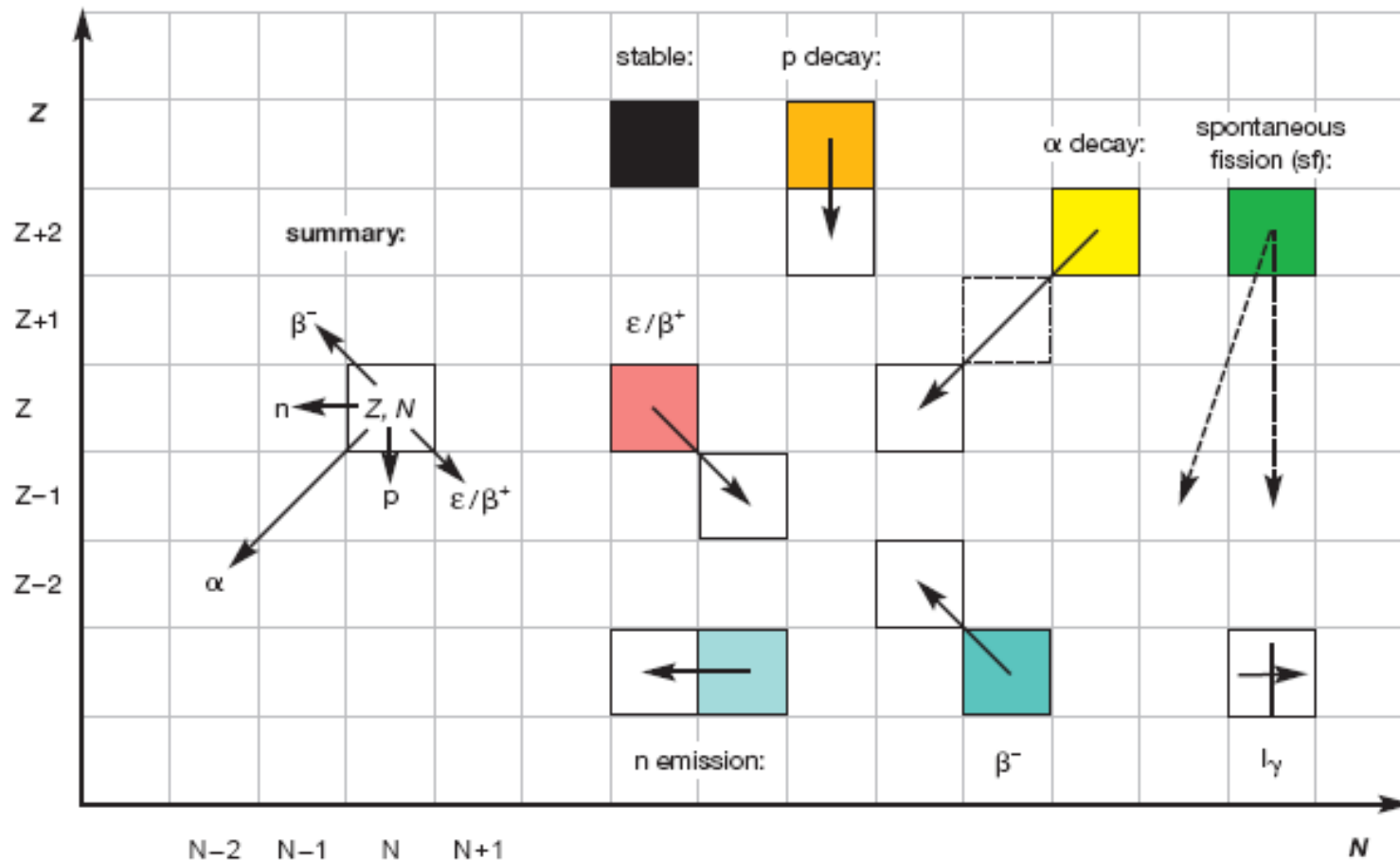
Chemical elements - white

Multiple decay modes

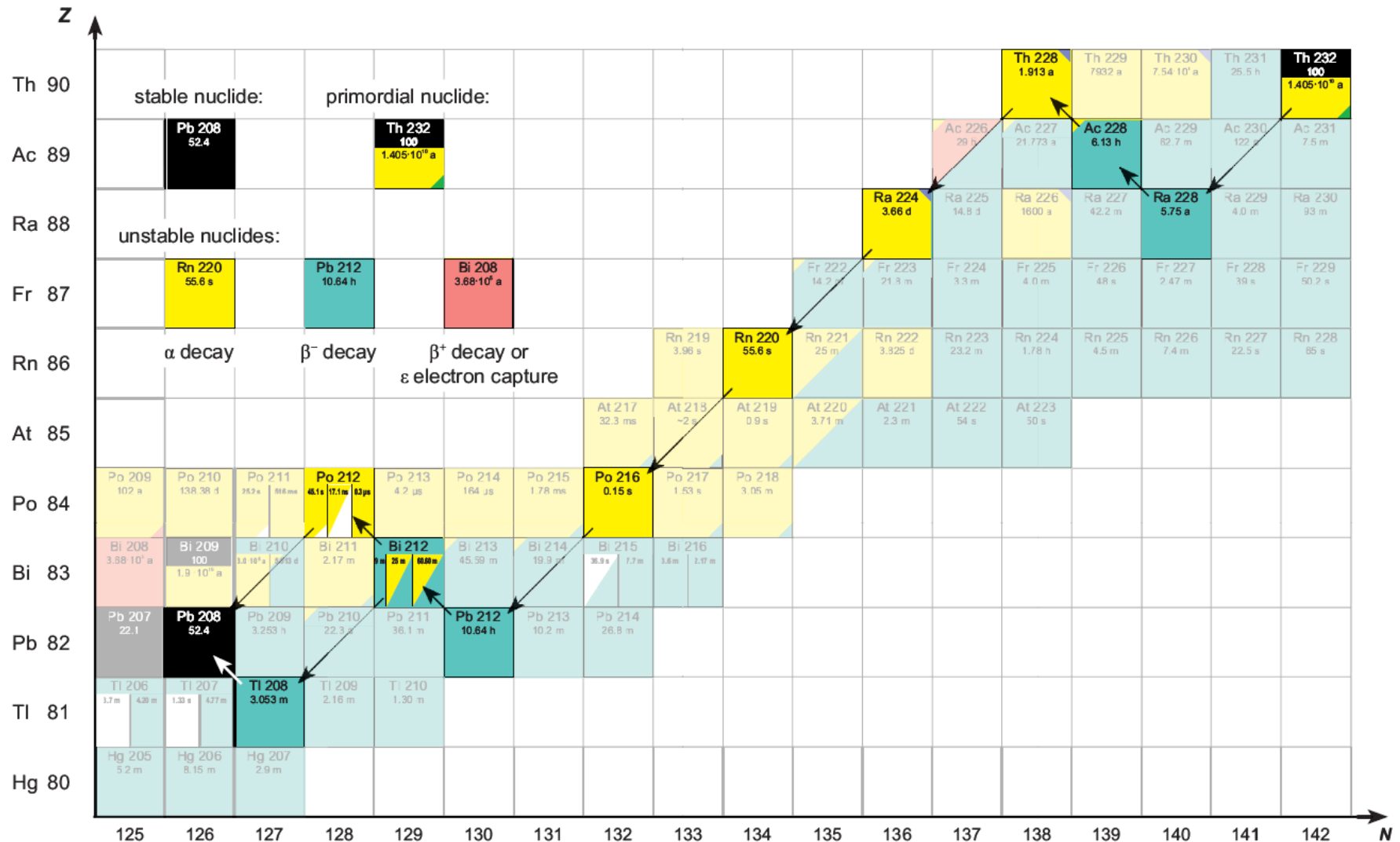
Large and small triangles



Decay processes on the KNC



Decay processes on the KNC



More info...



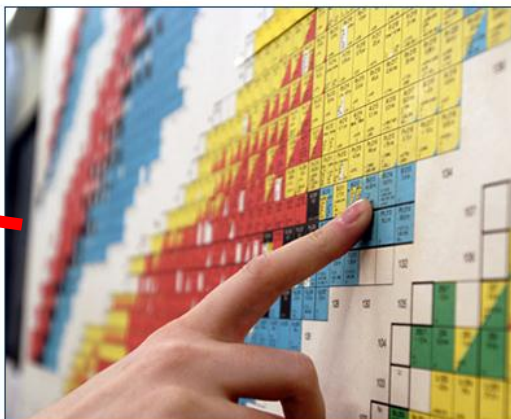
... web driven nuclear science

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Thursday, March 14, 2013

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- Ask an Expert
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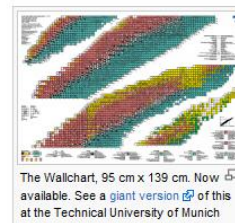


What is Nucleonica?

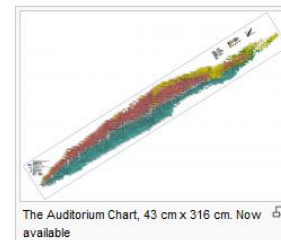
» Nucleonica is an innovative professional and technical resource for creation and competence building for the worldwide nuclear science community. The portal has grown to become the leading online resource for nuclear sciences and is particularly suitable for education and training of scientists, engineers and technicians in the nuclear domain. Our portal enables researchers and specialists to make complex and precise calculations in state-of-the-art fashion.



The Fold-out Chart (A4). Now available



The Wallchart, 95 cm x 139 cm. Now available. See a [giant version](#) of this at the Technical University of Munich



The Auditorium Chart, 43 cm x 316 cm. Now available



The Karlsruhe Nuclide "Carpet" with CERN logo (approximate dimensions 100 cm x 650 m). Now available

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Pages in category "KNC"

The following 15 pages are in this category, out of 15 total.

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■ 50th Anniversary of the KNC

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■ Contemporary Science Posters

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■ Decay modes
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■ Karlsruhe Nuclide Chart, 7th edition
■ Karlsruher Nuklidkarte, 7. Auflage

N

■ Nuclide "Carpet"

O

■ Online Shop

P

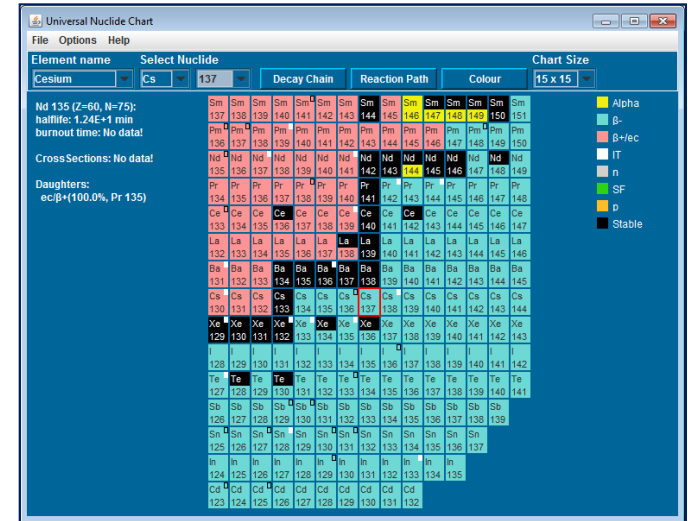
■ Publications & Press

S

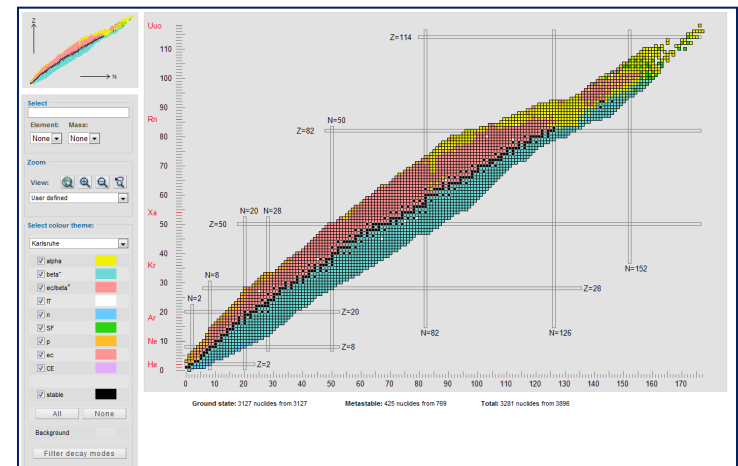
■ ScienceCinema
■ Short History of the KNC

Electronic Nuclide Charts in Nucleonica

Universal Nuclide Chart (UNC – decay chain simulator)

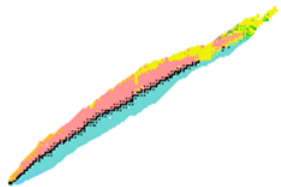


Nuclide Explorer (connected with other Nucleonica tools)



Universal Nuclide Chart

> Nuclide Explorer



» Actual Chart: Karlsruhe

> Search Nucleonica Documentation

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> Application Centre

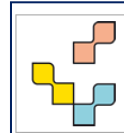
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- » Fission Yields
- » [Universal Nuclide Chart](#)

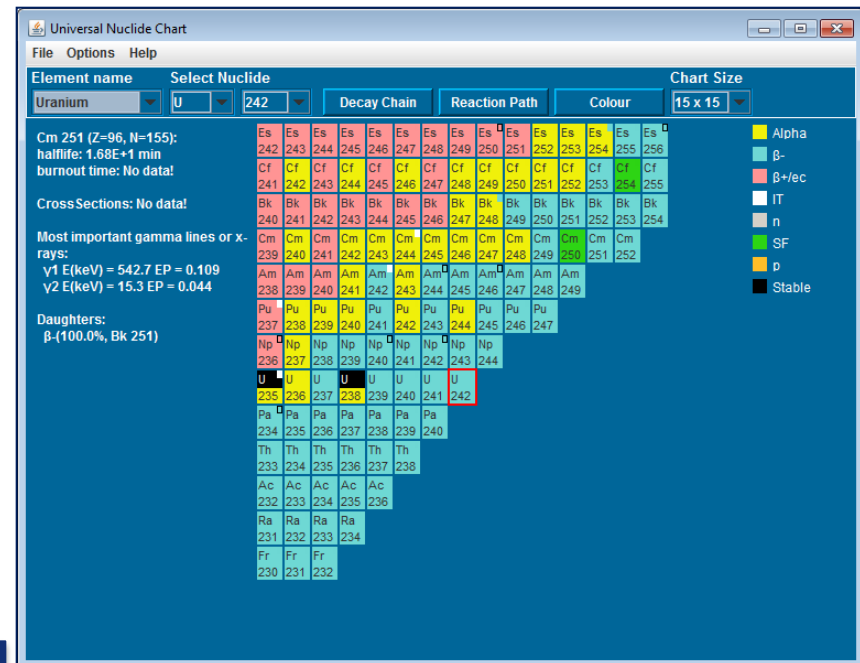
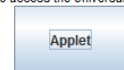
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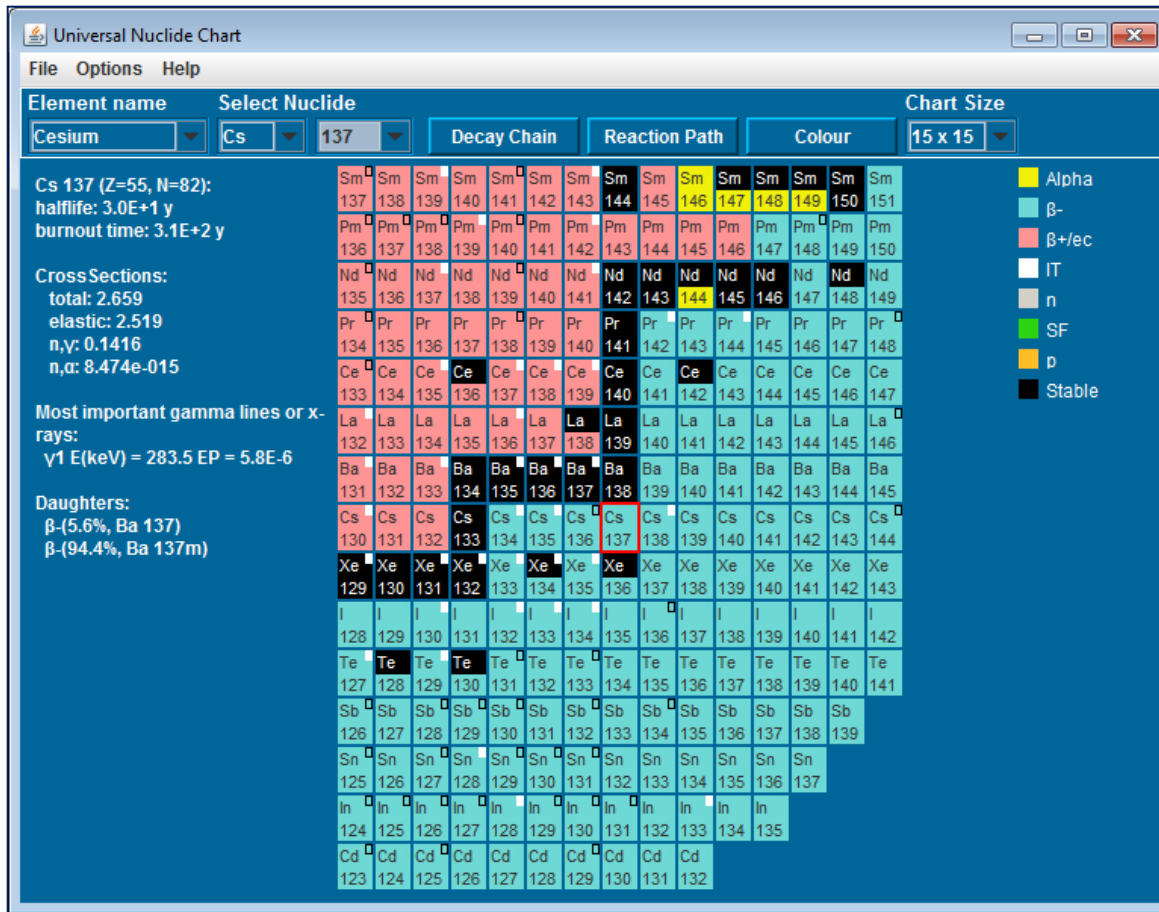


Universal Nuclide Chart

Click here to access the Universal Nuclide Chart



Nuclear Data in UNC



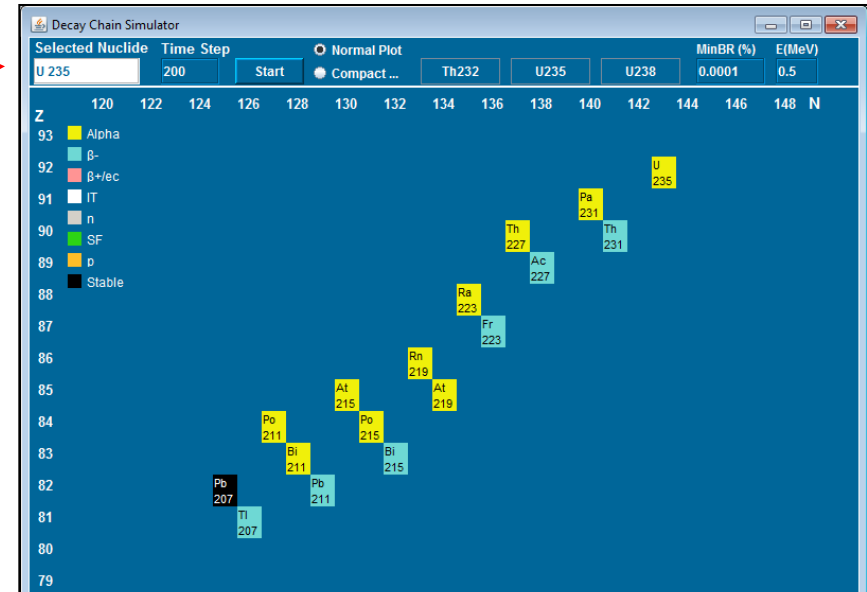
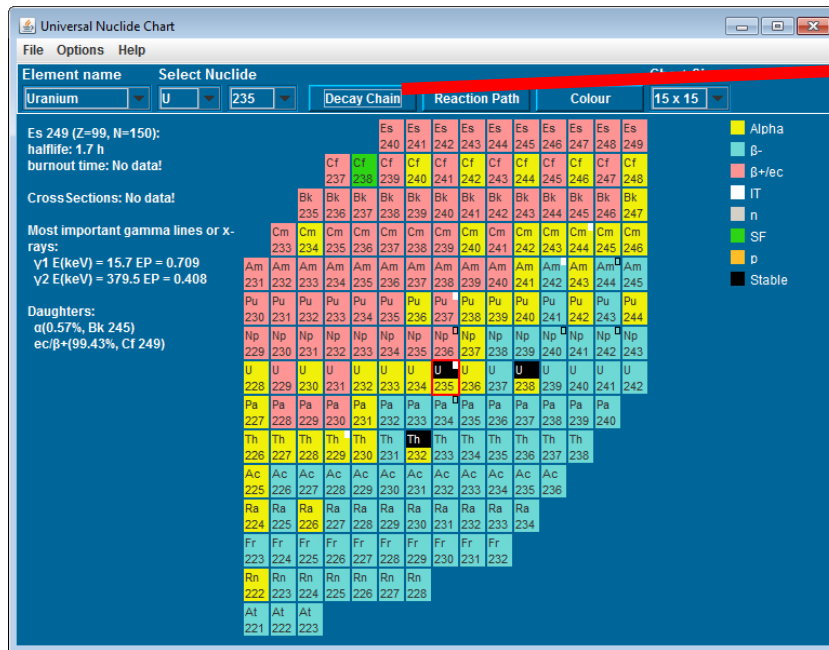
The Selected Nuclide is in the middle of the Chart

Mouse pointer:
For the pointed nuclide the most important nuclear data is shown on the left side

Decay Chain button

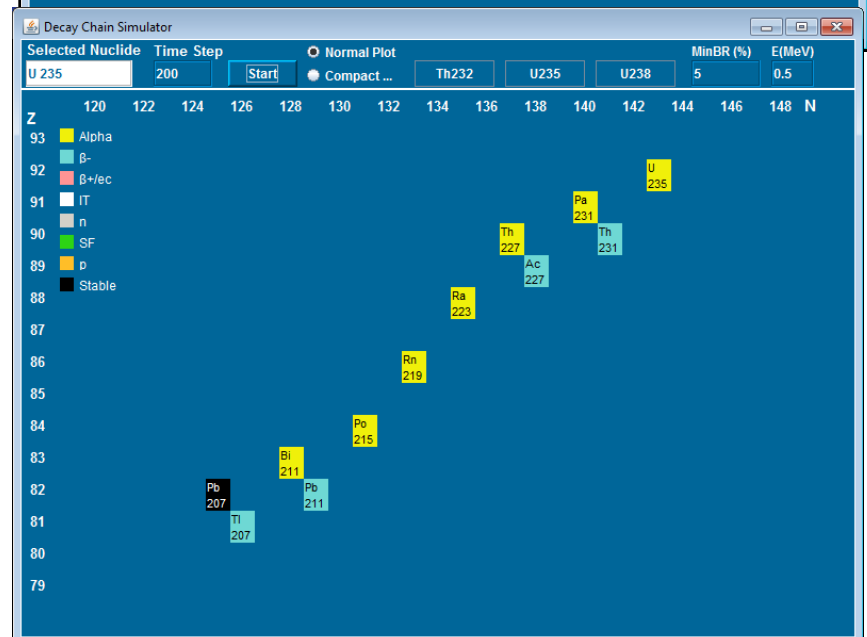
Reaction Path button

Decay chain of U-235

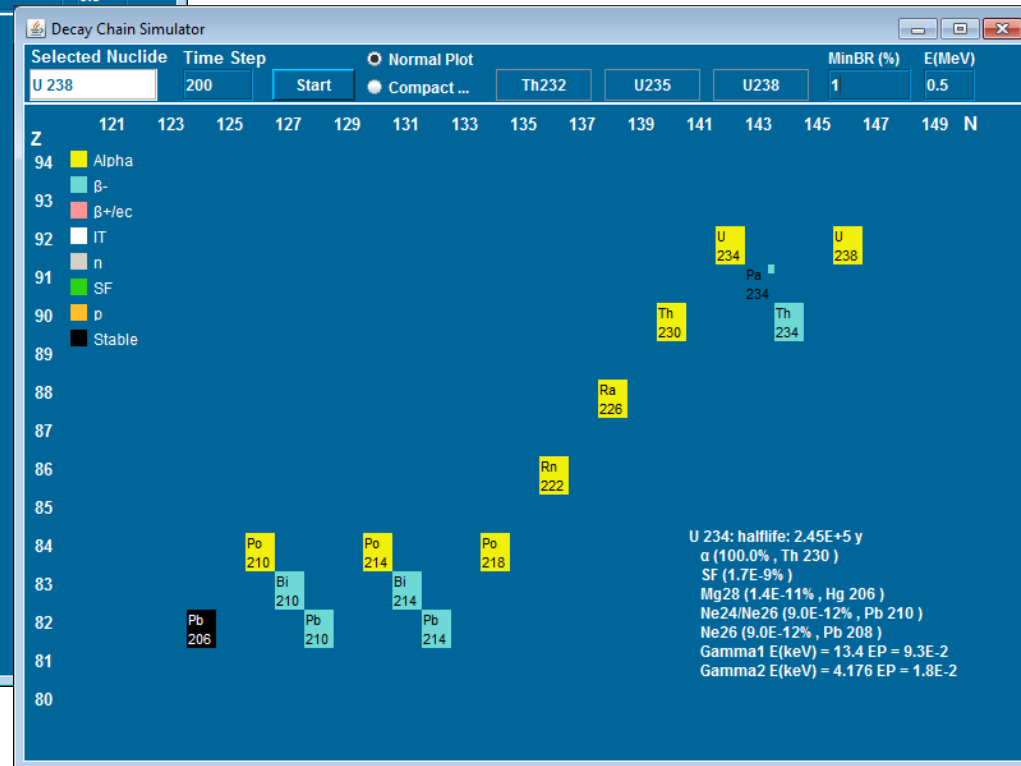
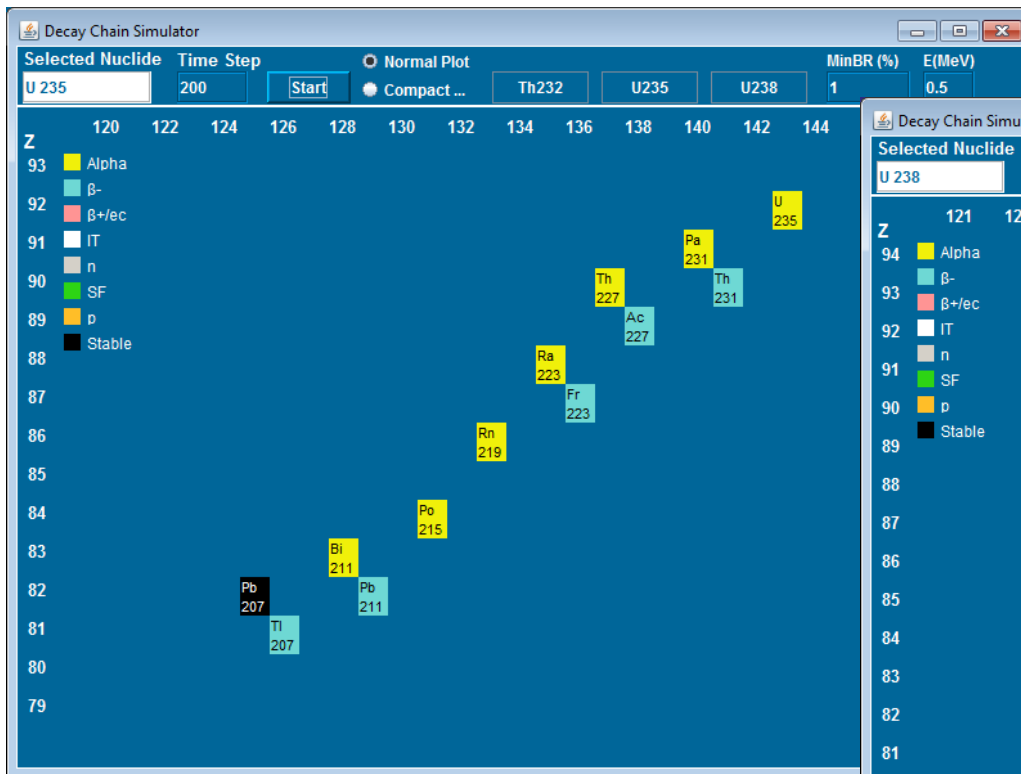


Set MinBr(%) to 5%: some decay path are not displayed anymore

E(MeV): causes blinking alarm on nuclides with higher:
gamma energy * emission probability



Decay chains of U-235 and U-238



Exercises

Universal Nuclide Chart

1. In the decay chain of U-238 find the nuclide which emits gamma photons with 1001 keV.

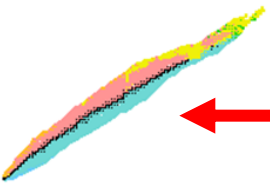
(Pa-234m)

2. In the decay chain of U-235, Ac-227 has alpha decay with BR 1.38% to Fr-223. Switch of all decays from the display which have less than 2% branching ratio. (MinBR%=2)

3. Switch off the blinking of the Tl-208 on the decay chain of Th-232.

Nuclide Explorer

» Nuclide Explorer



» Actual Chart: Karlsruhe

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Nuclide Search / Radiation Search

nucleonica [wiki]

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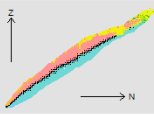
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Select

Element: Mass:

None None

Zoom

View: 

User defined

Select colour theme:

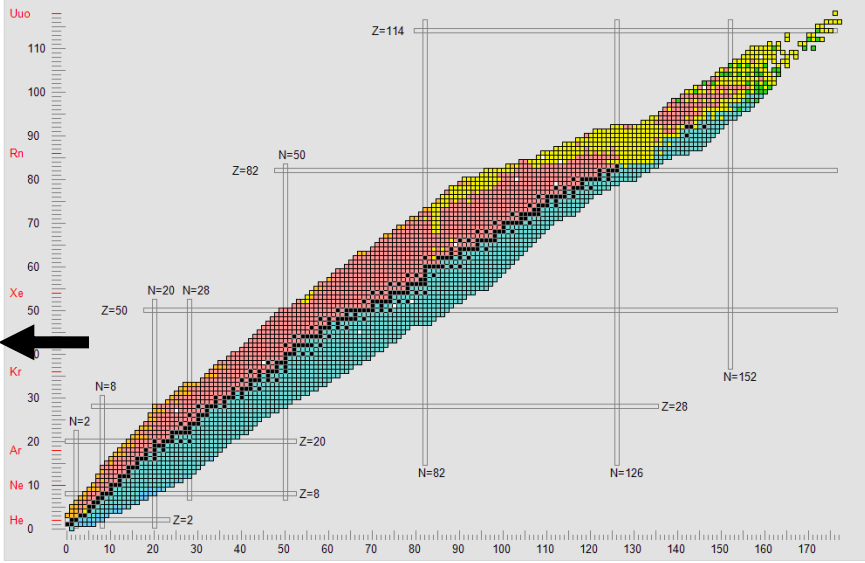
Karlsruhe

- ☒ alpha
- ☒ beta⁻
- ☒ e⁺/beta⁺
- ☒ IT
- ☒ n
- ☒ SF
- ☒ p
- ☒ ec
- ☒ CE
- ☒ stable

All None

Background

Filter decay modes

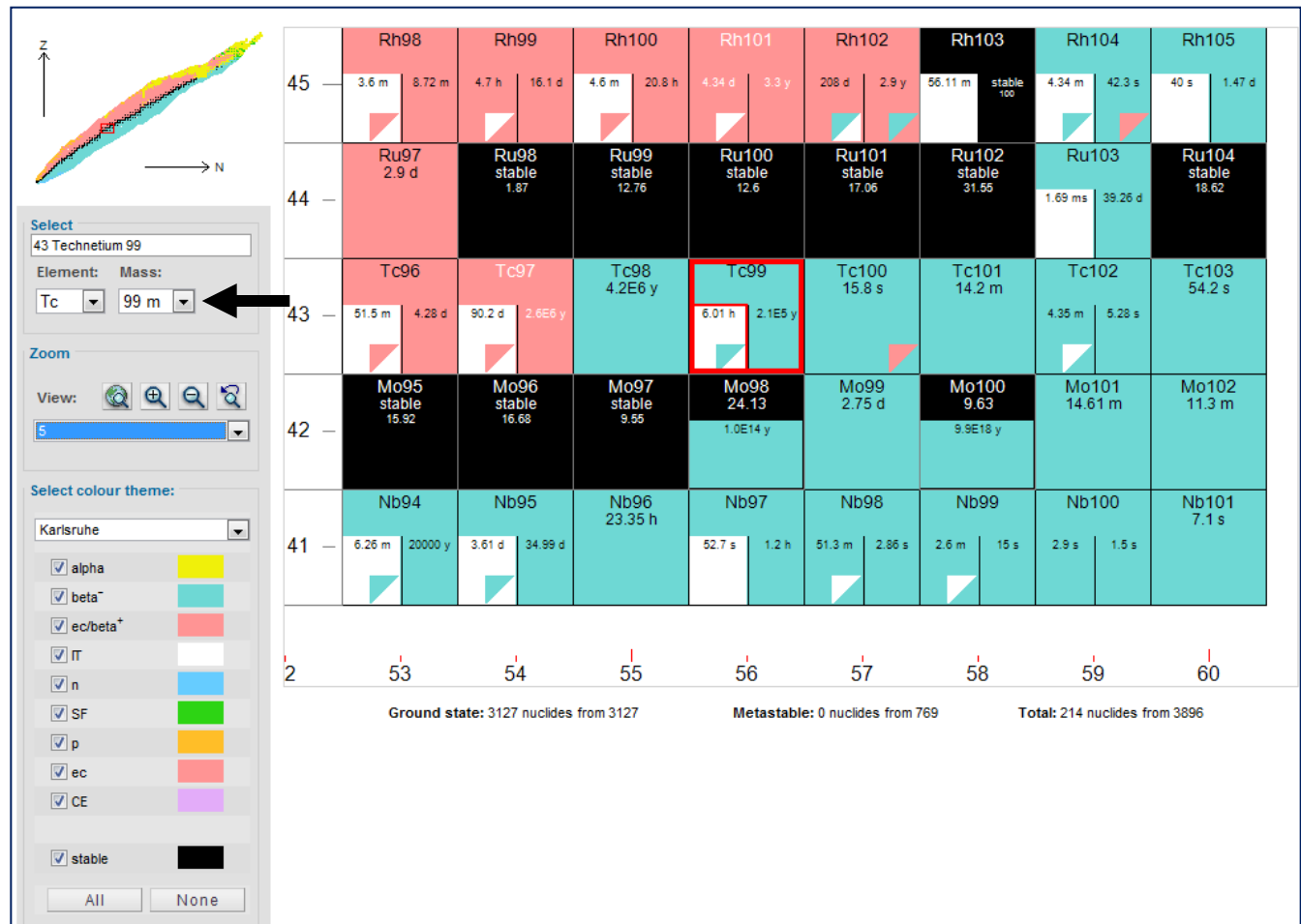


Ground state: 3127 nuclides from 3127 Metastable: 425 nuclides from 769 Total: 3281 nuclides from 3896

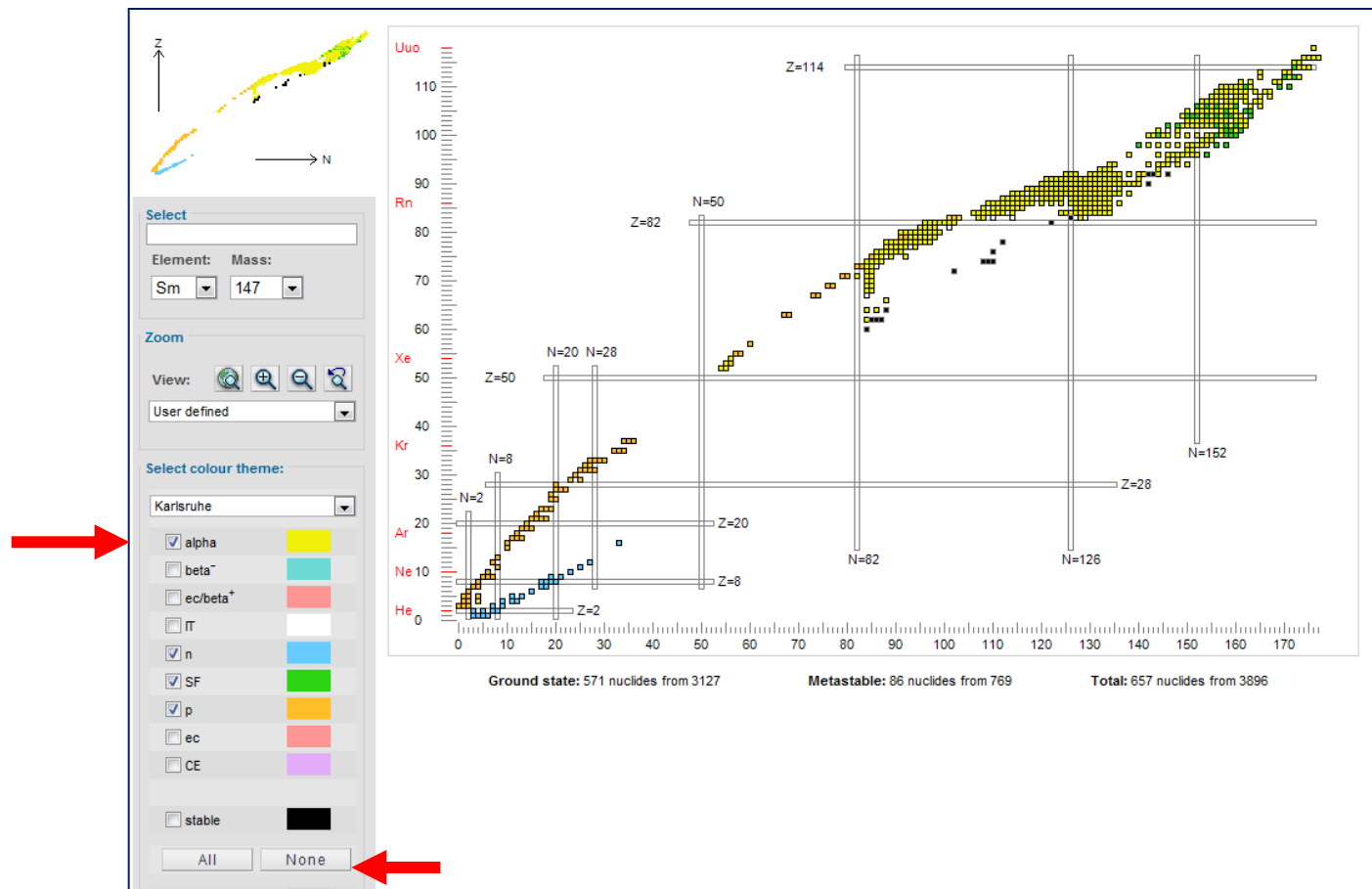
Colour scheme is changeable

Decay modes can be filtered

Nuclide Tc-99m



Nuclides with alpha, p and n main decay modes and SF nuclides

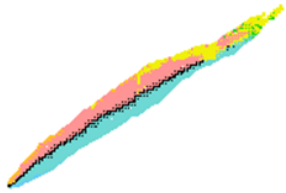




European
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Nuclide Data Sheets

► Nuclide Explorer



» Actual Chart: Karlsruhe

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Nucleonica Search / Radiation Search



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Nuclide selector

Cs137
30.06 y

Nuclide Datasheets
55 Cesium

Current Chart: Karlsruhe

Element: Cs Mass: 137

Reference Data | Description | Derived Data | Cross Sections | Radiations | Prompt Gammas | Select Print Outputs

» Reference Data Notes

Nuclide	137 55 Cs 82		
Density	1.93 g/cm ³		
Mass Excess	-86545.599 (± 455) keV		
Atomic Mass	136.907089473 (± 487) u		
Half-life	30.04 (± 3) y		
Spin	7/2 h		
Parity	+		
Binding Energy	8.38896 MeV/nucleon		
Abundance	-		
Effective Dose Coefficient Inhalation	3.9E-08 (Sv/Bq)		
Effective Dose Coefficient Ingestion	1.3E-08 (Sv/Bq)		
Mean Decay Energies			
Alpha	0 (MeV)		
Electron	187.871 (keV)		
Photon	0.0016443 (keV)		
Type of decay	Branching Ratio	Decay Energy,Q	Daughters
β-	0.0560055	1.17563 (MeV)	56 Ba 137
β-	0.943995	0.513971 (MeV)	56 Ba 137m
Type of parent decay	Branching Ratio	Decay Energy,Q	Parents
β-	1	4.172 (MeV)	54 Xe 137

Download ☒ Excel ☐ CSV Separator: Semicolon (;) ☒ Use field qualifier (*)

Nuclide Data Sheets

Cs137
30.06 y

Nuclide Datasheets

55 Cesium

Current Chart: Karlsruhe

Question

Element Mass
Cs 137

Reference Data Description Derived Data Cross Sections Radiations Prompt Gammas Select Print Outputs

```
/ENSDF/          55-Cs-137 ENSDF      EVAL-AUG97 CONVERSION OF ENSDF
----JEFF-31      DIST-FEB05          090205
----RADIOACTIVE DECAY DATA
----END-----FORMAT
```

```
** JEFF-3.1 Radioactive Decay Data File **
** Compiled at the NEA Data Bank - Feb 2005 **
** Original data taken from: ENSDF **
```

```
* Converted from ENSDF by using the SDF2NDF code (1) *
* (the CEA-Bruyeres version of the RADLST program). *
* (1) O. Bersillon and J. Blachot, to be published. *
```

```
137CS DECAY 30.04 Y 3 I(min) = 0.0E+00 %
Ex = 0.0 keV 1 decay mode(s)
```

```
137CS B- DECAY Q = 1175.6300 keV 0.1700
Branching 100.0000 % 0.0000
Br*Q = 1175.6300 keV 0.1700
1 isomeric state(s)
```

```
Ex = 0.0000 keV 5.6005 %
Ex = 661.6590 keV 94.3995 %
```

```
Mean alpha energy 0.0000 keV 0.0000
Mean beta energy 187.8706 keV 0.9044
Mean conv. e- energy 0.0000 keV 0.0000
Mean Auger e- energy 0.0000 keV 0.0000
Mean gamma energy 0.0016 keV 0.0000
Mean X energy 0.0000 keV 0.0000
```

Element Mass
Cs 137

Reference Data Description Derived Data Cross Sections Radiations Prompt Gammas Select Print Outputs

Neutron Induced Reactions

Library JEFF-3.2

Reaction / Neutron Energy	2200-m/s (Barns)	Maxwell Average (Barns)	Resonance Integral (Barns)	14 MeV (Barns)	Fission (Barns)
total	2.659	2.644	89.8	4.981	0.068
elastic	2.519	2.519	89.2	2.922	0.073
inelastic				0.08532	0.9839
n,2n				1.969	0.003348
n,p	0.1416	0.1254	0.5985	0.0008956	0.006821
n,d				0.001254	2.028E-06
n,t				0.0004759	7.054E-07
n,He3				5.039E-05	5.221E-08
n,a	8.474E-15	1.677E-14	3.277E-08	5.907E-07	5.632E-10
				0.000691	1.923E-06

Download Excel CSV Separator: Semicolon (;) Use field qualifier (")

Click here for Graphs of cross-sections from JENDL-3.2

- Nuclide
- Pointwise cross-sections
- Average cross-sections
- (n,xn) cross-sections

Element Mass
Cs 137

Reference Data Description Derived Data Cross Sections Radiations Prompt Gammas Select Print Outputs

Half-life	9.480E+08 (9) s
Decay constant	7.312E-10 (7) /s
Average or mean lifetime	4.34E+01 y
Specific Activity	3.22E+12 Bq/g
Heat Generation:	
Isotopic Power (a)	0.00E+00 W/g
Isotopic Power (a+β)	9.67E-02 W/g
Isotopic Power (a+β+γ)	9.67E-02 W/g
Gamma Emission:	
Specific Gamma Dose Rate in air at 1m.	2.38E-07 μSv/(MBq h)
Specific Gamma Exposure Rate in air at 1m.	2.04E-07 μGy/(MBq h)
Gamma Dose Rate Constant (vacuum)	2.36E-07 mSv m²/GBq h
Radiotoxicity:	
Annual Limit of Intake (ALI) for Inhalation	5.13E+05 Bq
Annual Limit of Intake (ALI) for Ingestion	1.54E+06 Bq
Derived air concentration (DAC)	2.14E+02 Bq/m³
Derived water concentration (DWC)	1.69E+03 Bq/litre
Packaging & Transport:	
Activity limits for special form materials, A1	2 TBq
Activity limits for special form materials, A2	0.6 TBq
Mass (A1)	6.22E-01 g
Mass (A2)	1.87E-01 g

Element Mass
Cs 137

Reference Data Description Derived Data Cross Sections Radiations Prompt Gammas Select Print Outputs

Nucleonica
☒ Gamma Rays ☒ Beta Rays

Update ☒ Show details

Gamma Rays

Number of lines: 1
Sum E.P. (eV per disintegration): 1.64E+00

Energy, E (keV)	Δ E (keV)	Emission Probability, E.P.	Δ E.P.	E x E.P. (keV)	Qtotal	Qk	QL
283.5	0.1	5.8E-06	8.00E-07	0.0016	0	0	0

Download Excel CSV Separator: Semicolon (;) Use field qualifier (")

Graph

Beta Rays

Number of lines: 3
Sum E.P. (eV per disintegration): 5.51E+05

End Point, E (keV)	Δ E (keV)	Emission Probability, E.P.	Δ E.P.	Energy x Emission Probability (keV)
513.966	0.170025	0.944	2.00E-03	485.2
1175.62	0.169998	0.056	2.00E-03	66
892.122	0.197229	5.8E-06	8.00E-07	0.0052

Download Excel CSV Separator: Semicolon (;) Use field qualifier (")

Graph

Exercises

Nuclide Explorer

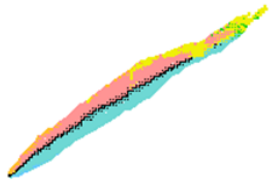
1. Switch the colour scheme of Nuclide Explorer to Binding Energy and switch it back to Karlsruhe.
2. Switch off the colours of all radioactive nuclides. Switch on colours after.
3. What are the daughters of Cs-137? (Ba-137, Ba-137m)

Nuclide Data Sheets

1. What are the daughters of Cs-137? What is the most important gamma line of Cs-137?(283.5 keV, EP=5.8E-6)
2. What is the daughter of Ba-137m? What is the most important gamma line of Ba-137m?(661 keV, EP=90.1%)
3. For the decay of Pu-239, what is the maximum alpha particle energy?(5.156 MeV)

Nuclide Data Search

> Nuclide Explorer



» Actual Chart: Karlsruhe

> Search Nucleonica Documentation

 Nucleonica / Radiation Search

nucleonica
[wiki]

> Application Centre

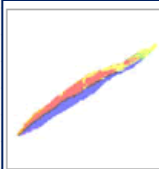
- » Mass Activity Calculator
- » **New:** Mass Activity Converter
- » Decay Engine
- » **New:** Decay Engine++
- » Dosimetry & Shielding
- » Range & Stopping Power
- » In Silico Dosimetry
- » webKORIGEN
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- » Gamma Library
- » webGraph

> Data Centre

- » Physical Constants
- » Nuclide Explorer
- » Nuclide Datasheets (Reference Data, Decay Data, Cross Sections, Radiations)
- » Nuclide Search / Radiation Search
- » Nuclear Data Retrieval (Nuclide Search, Radiation Search, Decay Data)
- » Fission Yields
- » Universal Nuclide Chart

> Knowledge Centre

- » Nuclear News



Nuclear Search / Radiation Search

Questions, remarks

Nuclide Search

Radiation Search

Advanced Search

Tabs

Atomic number Z: Element:

Mass number A: -

Half-life: -

☐ Stable/Primordial ☐ Isomers ☐ Decay Mode

Table display options

- | | |
|--|--|
| <input checked="" type="checkbox"/> Decay mode | <input type="checkbox"/> Parity |
| <input checked="" type="checkbox"/> Half-life | <input type="checkbox"/> Daughter |
| <input checked="" type="checkbox"/> Abundance | <input type="checkbox"/> Branching Ratio |
| <input type="checkbox"/> Spin | <input type="checkbox"/> Q-Value |

CPU time / Total time (sec): 0.36 / 1.7

Search returned 5 results, Number of nuclides: 3

Nuclides	Decay	Half-life	Abundance (atom %)
83 Bi 205	ec/β+	15.31 (± 4) d	
83 Bi 205	ec/β+	15.31 (± 4) d	
83 Bi 206	ec/β+	6.243 (± 3) d	
83 Bi 210	α	5.012 (± 5) d	
83 Bi 210	α	5.012 (± 5) d	
3	5	Page: 1 / 1	

☒ Excel ☐ CSV Separator: ☒ Use field qualifier ("")

Radiation search

Nuclide Search
Radiation Search
Advanced Search

☒ Gamma and X-Rays
 Energy:
 +/- keV
☐ Alpha
 +/- keV
 +/- keV

Emission probability: -
 Atomic number Z: Element:
 Mass number A: -
 Half-life: s - s

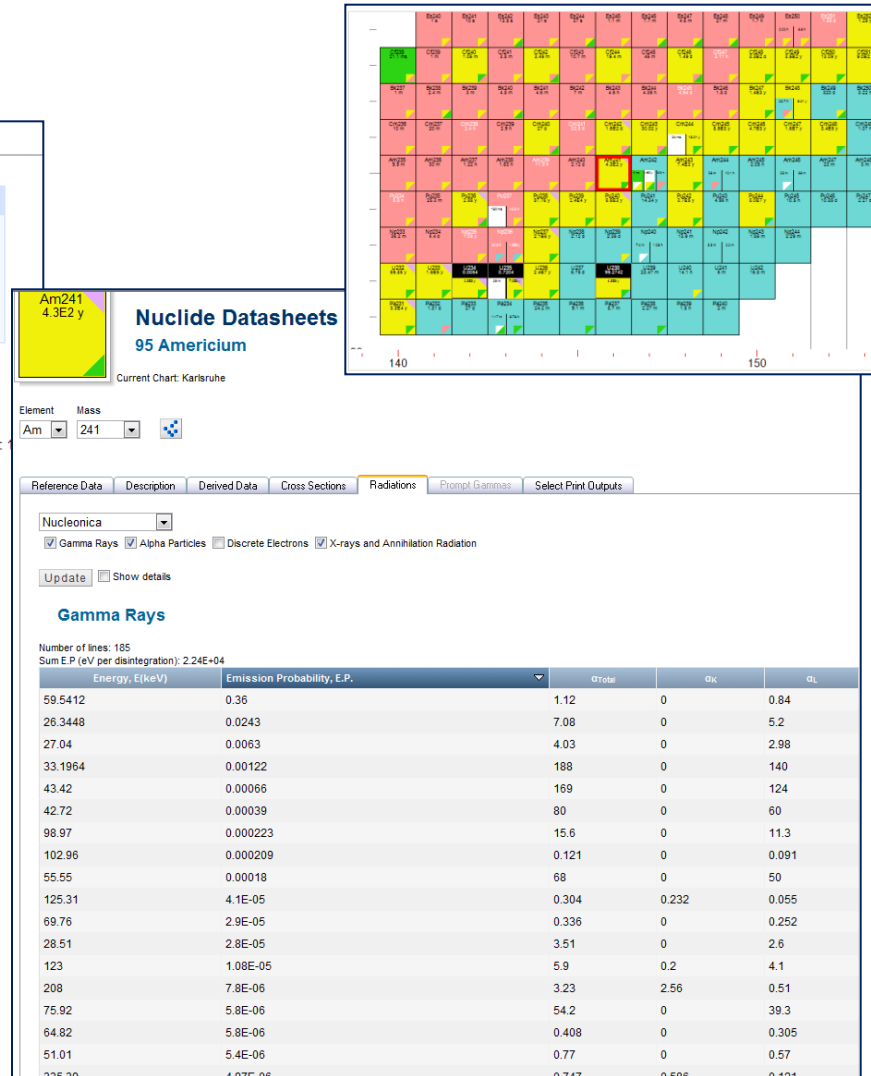
Table display options

☐ Energy uncertainty
☐ E.P. uncertainty
☒ Half-life
☐ FD

CPU time / Total time (sec):

Search returned 19 results, Number of nuclides: 4

Nuclides	Gamma and X-Rays (keV)	Emission Probability	Half-life
95 Am 241	102.96	0.000209	432.8 (± 7) y
91 Pa 231	102.85	0.00171	32.76 (± 11) ky
91 Pa 231	102.8	0.00015	32.76 (± 11) ky
91 Pa 231	102.1	0.000896	32.76 (± 11) ky
91 Pa 228	102	0.00042	22 (± 1) h
67 Ho 161	101.99	0.000156	2.48 (± 12) h
95 Am 241	101.07	2.07E-05	432.8 (± 7) y
91 Pa 231	60.5	5.5E-05	32.76 (± 11) ky
91 Pa 228	60.3	9.7E-05	22 (± 1) h
91 Pa 228	60.3	9.7E-05	22 (± 1) h
91 Pa 228	59.8	2.8E-05	22 (± 1) h
95 Am 241	59.5412	0.36	432.8 (± 7) y
67 Ho 161	59.24	0.00605	2.48 (± 12) h
91 Pa 228	28.8	0.000152	22 (± 1) h
67 Ho 161	28.69	1.17E-05	2.48 (± 12) h
95 Am 241	28.51	2.77E-05	432.8 (± 7) y
91 Pa 228	28.3	2E-05	22 (± 1) h
91 Pa 231	27.36	0.111	32.76 (± 11) ky
95 Am 241	27.04	0.00626	432.8 (± 7) y
4	19		Page: 1 / 1



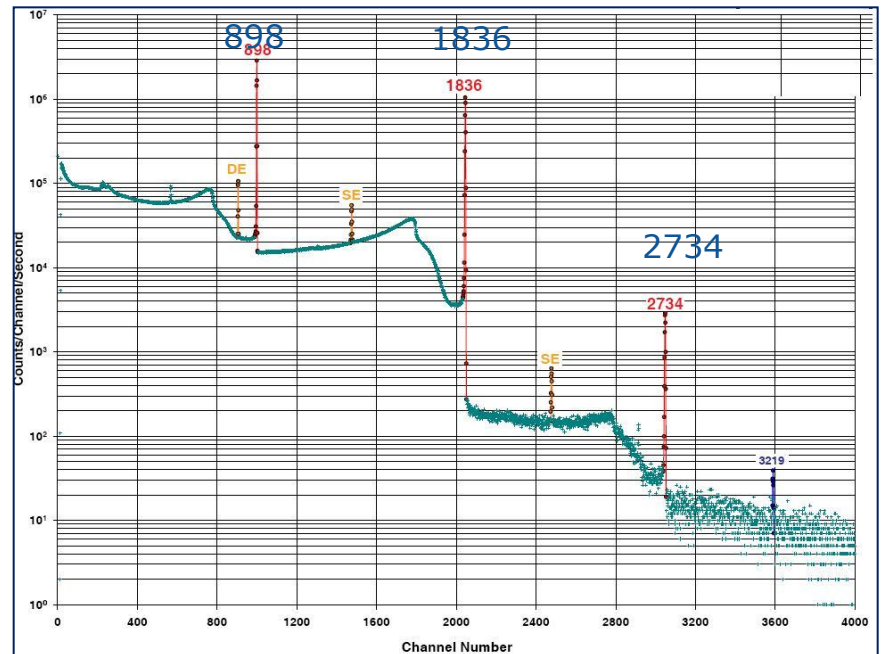
Exercises

Nuclear Data Search

1. Find the nuclides with gamma lines at 81, 303 and 356 keV with an uncertainty of ± 1 keV. (Pa-228, Ba-133)

2. Find the Cs isotopes which have a half-life in the range of 2 weeks -100 years. (Cs-134, Cs-137)

3. See gamma spectrum below – to which isotope does this correspond? (Y-88 or Rb-88)



Dose Coefficients (ICRP 68 & 72)

ICRP Database Search

Data source	Type	Element(s)
<input checked="" type="checkbox"/> ICRP 68	<input checked="" type="checkbox"/> Ingestion	<input checked="" type="radio"/> Element
<input checked="" type="checkbox"/> ICRP 72	<input checked="" type="checkbox"/> Inhalation	<input type="radio"/> All

Dose coefficient quick link

Search returned 13 results

Nuclides	ICRP 68: Effective dose coefficient (inhalation) $e(50)_{inh}$ (Sv/Bq)	ICRP 68: Effective dose coefficient (ingestion) $e(50)_{ing}$ (Sv/Bq)	ICRP 72: Effective dose coefficient (inhalation) $e(50)_{inh}$ (Sv/Bq)	ICRP 72: Effective dose coefficient (ingestion) $e(50)_{ing}$ (Sv/Bq)
94 Pu 234	2.20E-08	1.60E-10	2.40E-08	1.60E-10
94 Pu 235	2.60E-12	2.10E-12	1.50E-12	2.10E-12
94 Pu 236	1.80E-05	8.60E-08	1.00E-05	8.70E-08
94 Pu 237	3.60E-10	1.00E-10	3.90E-10	1.00E-10
94 Pu 238	4.30E-05	2.30E-07	1.10E-04	2.30E-07
94 Pu 239	4.70E-05	2.50E-07	1.20E-04	2.50E-07
94 Pu 240	4.70E-05	2.50E-07	1.20E-04	2.50E-07
94 Pu 241	8.50E-07	4.70E-09	2.30E-06	4.80E-09
94 Pu 242	4.40E-05	2.40E-07	1.10E-04	2.40E-07
94 Pu 243	1.10E-10	8.50E-11	8.60E-11	8.50E-11
94 Pu 244	4.40E-05	2.40E-07	1.10E-04	2.40E-07
94 Pu 245	6.50E-10	7.20E-10	4.30E-10	7.20E-10
94 Pu 246	7.60E-09	3.30E-09	8.00E-09	3.30E-09

☒ Excel
 ☐ CSV
 Separator:
☒ Use field qualifier (")

Physical Constants, Conversion Factors, Radiological limits...



Physical Constants

Physical Constants

Conversion Factors

Prefixes / Greek Alphabet

Radiological Limits

Physical Constants

Create new constant

Quantity	Symbol	Numerical Value	Uncertainty	Unit	Name In Script	
Speed of light in vacuum	c	299792458	0	ms ⁻¹	Const_c	Edit
Newtonian constant of gravitation	G	6.67428E-11	67	m ³ kg ⁻¹ s ⁻²	Const_G	Edit
Magnetic constant	μ_0	1.2566370614E-06	0	N/A ²	Const_mu0	Edit
Electric constant	ϵ_0	8.854187817E-12	0	Fm ⁻¹	Const_eps0	Edit
Planck constant	h	6.62606896E-34	33	Js	Const_planck	Edit
reduced Planck constant	\hbar	1.054571628E-34	53	Js	Const_planck_2pi	Edit
Atomic mass constant	u	1.660538782E-27	83	kg	Const_u	Edit
Energy equivalent of atomic mass constant	u	931.494028	23	MeV	Const_u_energy	Edit
Neutron mass	m_n	1.674927211E-27	84	kg	Const_mn	Edit
Neutron mass	m_n	1.00866491597	43	u	Const_mn_u	Edit
Neutron mass	m_n	939.565346	23	MeV	Const_mn_energy	Edit
Proton mass	m_p	1.672621637E-27	83	kg	Const_mp	Edit
Proton mass	m_p	1.00727646677	10	u	Const_mp_u	Edit
Proton mass	m_p	938.272013	23	MeV	Const_mp_energy	Edit



Physical Constants

Physical Constants, Conversion Factors, Radiological limits...

Physical Constants

Conversion Factors

Prefixes / Greek Alphabet

Radiological Limits

Radiological Limits

Workers

Apprentices and Students

Members of the Public

Workers

Dose Limits for exposed workers	Euratom	ICRP	IAEA	Germany
Limit on effective dose for exposed workers in a consecutive 5 years period:	100 mSv	20 mSv/y	20 mSv/y	20 mSv/y
Maximum effective dose in any single year:	50 mSv/y	50 mSv/y	50 mSv/y	50 mSv/y
Equivalent dose limit to the foetus, accumulated over the period of time between declaration of pregnancy to the delivery date:	1 mSv	2 mSv		1 mSv
Pregnant woman				2 mSv/m
Total work life (50 y)				400 mSv
Partial body exposure:				
Limit on equivalent dose for the lens of the eyes:	150 mSv/y	150 mSv/y	150 mSv/y	150 mSv/y
Limit on equivalent dose for the skin:	500 mSv/y	500 mSv/y	500 mSv/y	500 mSv/y
Limit on equivalent dose for the hands, forearms, feet and ankles:	500 mSv/y	500 mSv/y	500 mSv/y	500 mSv/y

Fission Yields

Fission Yield: Number of atoms of a **specific nuclide** produced per 100 fission reactions

Independent Fission Yields: direct production of specific atoms - decay excluded

Cumulative Fission Yields: direct production + via decay

Chain Yield: Atoms of specific isobars ($A=\text{const}$) per 100 fission reactions
(KNC: U-235 and Pu-239 yields)

Te 137 2.5 s β^- 6.3, 6.8... γ 243, 554 469... βn	Te 138 1.4 s β^- βn	Te 139 >300 ns $\beta^-?$ $\beta n?$	Te 140 >300 ns $\beta^-?$ $\beta n?$	Te 141 >300 ns $\beta^-?$ $\beta n?$
Sb 136 923 ms β^- βn	Sb 137 492 ms β^- βn	Sb 138 350 ms β^- βn	Sb 139 93 ms β^- βn	Sb 140 >230 ns $\beta^-?$ $\beta n?$
Sn 135 530 ms β^- 8.9... γ 282, 925, 733 1207... βn	Sn 136 300 ms β^- βn	Sn 137 273 ms β^- βn	Sn 138 >230 ns $\beta^-?$ $\beta n?$	6.345 5.968
In 134 140 ms β^- βn	In 135 92 ms β^- βn	6.57 6.99	6.221 6.594	6.72 6.11

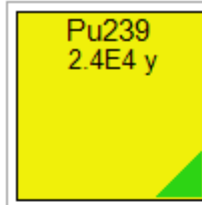
Fission Yields Module

> Application Centre

- » Mass Activity Calculator
- » **New:** Mass Activity Converter
- » Decay Engine
- » **New:** Decay Engine++
- » Dosimetry & Shielding
- » Range & Stopping Power
- » In Silico Dosimetry
- » webKORIGEN
- » Decay Engine for Large Nuclide Sets
- » Universal Nuclide Chart
- » Transport & Packaging
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- » Gamma Spectrum Generator Pro
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- » WESPA
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- » webGraph

> Data Centre

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- » Nuclide Explorer
- » Nuclide Datasheets (Reference Data, Derived Data, Cross Sections, Radiations)
- » Nuclide Search / Radiation Search
- » Nuclear Data Retrieval (Nuclide Search, Radiation Search, Dose Coefficients)
- » Fission Yields
- » Universal Nuclide Chart



Fission Yields 94 Plutonium

Current Chart: Karlsruhe

Element: Mass:

Pu 239

Select Fission Yields

Library: JEFF-3.1

Type of fission: Thermal fission

Fission Yields Settings

Element

Mass Number

Min Half-life

1

Days

Max Half-life

Seconds



Advanced comparison

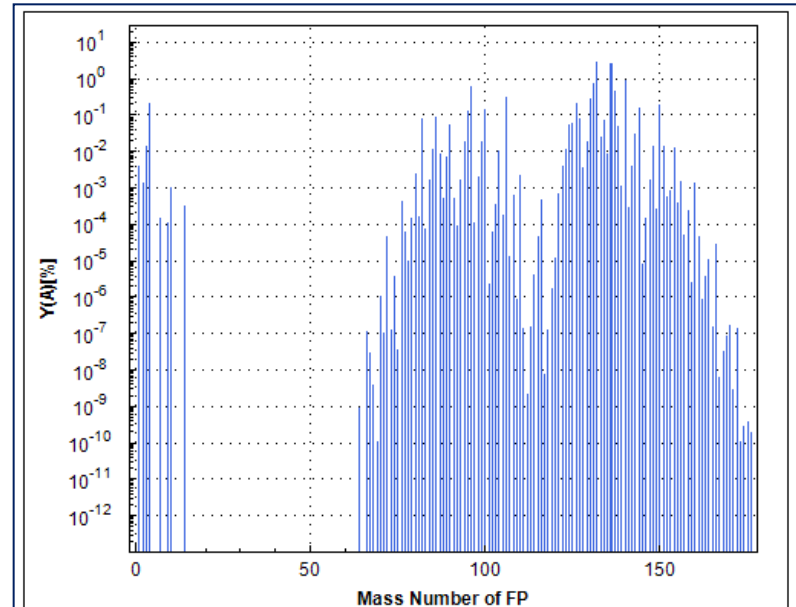
Results

Reset

Fission products of Pu-239

Total number of fission products: 306

	Nuclide	Half-life	Independent Yield	Error	Cumulative Yield	Error
Compare	52 Te 132	3.204 (± 13) d	2.94E-02	4.47E-03	5.09E-02	9.36E-04
Compare	54 Xe 136	2.10E+20 (± 0) y	2.70E-02	5.72E-03	6.90E-02	2.53E-03
Compare	56 Ba 140	12.765 (± 15) d	8.76E-03	2.84E-03	5.32E-02	5.86E-04
Compare	52 Te 131m	1.250 (± 8) d	6.85E-03	1.89E-03	9.04E-03	1.45E-03
Compare	40 Zr 96	3.9E+19 (± 9) y	5.82E-03	1.98E-03	4.93E-02	1.53E-03
Compare	55 Cs 137	30.04 (± 3) y	4.57E-03	1.62E-03	6.59E-02	8.03E-04
Compare	44 Ru 106	1.020 (± 2) y	2.98E-03	1.04E-03	4.19E-02	9.21E-04
Compare	52 Te 130	7.90E+23 (± 100) y	2.68E-03	7.95E-04	2.79E-02	6.70E-03
Compare	2 He 4	Stable	2.19E-03	1.18E-04	2.19E-03	8.98E-05
Compare	50 Sn 126	230 (± 14) ky	2.02E-03	3.86E-04	2.64E-03	4.71E-04
Compare	60 Nd 150	2.1E+19 (± 5) y	1.87E-03	5.22E-04	9.75E-03	1.27E-04
Compare	58 Ce 144	285.0 (± 2) d	1.63E-03	6.02E-04	3.75E-02	3.00E-04
Compare	42 Mo 100	9.9E+18 (± 7) y	1.44E-03	5.72E-04	6.84E-02	9.98E-03
Compare	40 Zr 95	64.032 (± 6) d	1.33E-03	4.84E-04	4.95E-02	9.90E-04
Compare	36 Kr 86	Stable	9.19E-04	3.01E-04	7.83E-03	1.85E-04
Compare	34 Se 82	1.21E+20 (± 17) y	8.29E-04	2.30E-04	2.31E-03	4.11E-04
Compare	51 Sb 127	3.85 (± 5) d	7.72E-04	2.50E-04	4.60E-03	2.67E-04
Compare	54 Xe 134	1.1E+16 (± 0) y	6.79E-04	2.40E-04	6.87E-02	3.57E-03
Compare	55 Cs 136	13.03 (± 7) d	5.88E-04	2.07E-04	7.60E-04	2.15E-04
Compare	38 Sr 90	28.79 (± 6) y	5.66E-04	2.07E-04	2.01E-02	
Compare	50 Sn 124	1.00E+17 (± 0) y	5.09E-04	1.25E-04	1.26E-03	
Compare	50 Sn 125	9.64 (± 3) d	4.99E-04	9.46E-05	5.46E-04	
Compare	56 Ba 138	Stable	4.70E-04	1.77E-04	6.11E-02	
Compare	58 Ce 143	1.379 (± 2) d	3.09E-04	1.15E-04	4.48E-02	
Compare	53 I 131	8.0233 (± 19) d	2.34E-04	8.14E-05	3.72E-02	
Compare	40 Zr 94	6.0E+15 (± 0) y	1.98E-04	7.28E-05	4.32E-02	
Compare	42 Mo 99	2.7475 (± 4) d	1.91E-04	6.85E-05	6.18E-02	
Compare	52 Te 129m	33.6 (± 1) d	1.87E-04	6.55E-05	5.65E-03	
Compare	51 Sb 126	12.4 (± 1) d	1.80E-04	6.21E-05	2.22E-04	
Compare	54 Xe 133m	2.188 (± 11) d	1.72E-04	6.25E-05	2.16E-03	
Compare	1 H 3	12.33 (± 2) y	1.42E-04	1.09E-05	1.42E-04	
Compare	61 Pm 151	1.1833 (± 16) d	1.40E-04	4.79E-05	7.76E-03	



Comparison of fissioning system

Libraries

Cs-137 for Pu-239 Thermal fission JEFF-3.1 library

S: Spontaneous fission
T: Thermal neutron induced fission
F: Fast neutron induced fission
H: High energy (14 MeV fusion neutrons) neutron induced fission

		<div>Pu239F</div>	<div>U235T</div>	<div>U238F</div>	<div>U233F</div>
Independent Yield	JEFF-3.1-Pu239T	Pu239F	U235T	U238F	U233F
Error (I)					
Cumulative Yield					
Error (C)					
Y(A)					
Error (A)					

Exercises

Fission Yields

1. Find the thermal neutron fission products of U-235. How many fission products are listed in JEFF?
(977)
2. Which fission products have the highest yields?
Give cumulative and independent.
(Te-134, Xe-134)
3. What is the cumulative fission yield of Cs-137?
(6.22E-2 or 6.22%)

Overview

Nuclide Charts

Karlsruhe Chart of Nuclides

Electronic Nuclide Charts in Nucleonica

Nuclear Data Search in Nucleonica

Thank You